TITLE: NETWORKED SOUND MASKING SYSTEM WITH CENTRALIZED SOUND MASKING GENERATION

FIELD OF THE INVENTION

[0001] The present invention relates to sound masking, and more particularly to a networked system with centralized sound masking generation.

BACKGROUND OF THE INVENTION

[0002] Sound masking systems are widely used in offices and similar workplaces where an insufficient level of background sound results in diminished speech privacy. Such environments suffer from a high level of noise distractions, and lower comfort levels from an acoustic perspective. Sound masking systems operate on the principle of masking which involves generating a background sound in a given area. The background sound has the effect of limiting the ability to hear two sounds of similar sound pressure level and frequency simultaneously. By generating and distributing the background noise in the given area, the sound masking system masks or covers the propagation of other sounds in the area and thereby increases speech privacy, reduces the intrusion of unwanted noise, and improves the general acoustic comfort level in the area or space.

[0003] Sound masking systems are of two main types: centrally deployed systems and independent self-contained systems. In a centrally deployed system, a central noise generating source supplies a series of loudspeakers installed throughout the physical area or space to be covered. The independent self-contained system comprises a number of individual self-contained sound masking units which are installed in the physical space. The sound masking units operate independently of each other, but may include a number of satellite

speakers which extend the range of each self-contained, i.e. master, sound masking unit. Most sound masking systems include the capability for broadcast announcements and music over the loudspeakers contained in the sound masking units.

[0004] The primary goal of sound masking systems is to provide an unobtrusive, effective masking sound that is adjustable for maximum consistency, and offers the ability to meet the requirements of the occupants. The masking output is preferably sufficient to accommodate the existing acoustic requirements of the workplace environment and adjustable to handle changes to the acoustic characteristics of environment which occur over time. Similar demands are placed on the system for the public address and music functions. In short, the preferred sound masking system would produce an output with a frequency and volume level that is controllable to produce the desired acoustic response for workplace zones ranging in size from the smallest to larger spaces.

[0005] Centralized systems are characterized by achieving uniformity of output, but not uniformity of acoustic response for the space. In a centralized system, the frequency spectrum of the sound masking output can only be adjusted at a centrally located equalizer, and as a result the sound masking output has the same frequency spectrum for all of the loudspeakers. Depending on the configuration of the centralized system, volume adjustments may be made for very large physical spaces, i.e. zones, by adjusting the amplifier output; for relatively smaller zones, volume adjustments are made by changing wiring connections or controls on the speaker enclosure, or by adjusting a hardwired zone volume control. In practice, it is difficult to accommodate environmental acoustic variations using a centralized system because the volume and frequency spectrum adjustments required for the typical physical zone size are too large to achieve a uniform acoustic result. A further disadvantage is that many of the adjustments for a centralized sound masking

system require an installer or technician to re-enter the ceiling space or to rewire the speakers in the system.

[0006] The independent self-contained system has a number of advantages over the centralized arrangement. The independent self-contained system is more effective in terms of sound generation, volume adjustment, and frequency adjustment which, in turn, improves the performance of such systems as compared to centralized systems. In particular, the independent self-contained system provides a defined non-frequency specific output range for the masking output spectrum, and adjustments can be made at each master sound masking unit. The volume controls for an independent self-contained system also provide more flexibility than in the centralized system, and provide for finer adjustments in smaller zones, in addition to centralized volume controls for large zone or global adjustment. However, with existing systems it is still necessary to re-enter the ceiling to adjust the frequency spectrum and volume output level for each master sound masking unit, and the controls for providing multi-unit volume zone adjustments require the hardwiring of the units.

[0007] While existing independent self-contained systems are more flexible than centralized systems in many regards, they do not satisfy all the requirements of an ideal sound masking system as discussed above. Furthermore, other shortcomings are associated with existing sound masking systems. In both centralized and independent self-contained systems, the public address and music volume controls are limited in the same manner as described above for sound masking output volume controls. Second, any centrally located controls only affect the output level for the speakers or sound masking units which have a hardwired connection. It will be appreciated that this severely limits the adjustability of the system to future changes unless at least some of the system is rewired. Third, adjustments to existing systems must be made on-site.

[0008] Accordingly, there remains a need for a networked sound masking system which exploits the advantages of individually controllable sound masking units, and the advantages of centralized sound masking generation, and which system is easily adaptable to changing sound qualities in a physical space or spaces in a building environment.

BRIEF SUMMARY OF THE INVENTION

[0009] The present invention provides a networked sound masking system with centralized sound masking signal generation and individually controllable sound masking units.

[0010] In a first aspect, the present invention provides a sound masking system for controlling the ambient noise level in a physical environment, the sound masking system comprises: (a) a communication network spanning at least a portion of the physical environment; (b) a plurality of sound masking units, some of the sound masking units include a communication interface for coupling the sound masking units to the communication network for receiving control signals and a sound masking signal over the communication network; (c) a control unit having a communication interface for coupling to the communication network for selectively transmitting the control signals and the sound masking signal over the communication network to the sound masking units, and the control signals include signals for controlling the operation of at least some of the sound masking units.

[0011] In another aspect, the present invention provides a sound masking system for shaping the ambient noise level in a physical environment, the sound masking system comprises: (a) a communication network spanning at least a portion of the physical environment; (b) a plurality of sound masking units, some of the sound masking units include a programmable controller and at least one digital component for controlling operation of an audio signal output circuit, and a communication interface for coupling the sound masking units to the

communication network, and the programmable controller being coupled to the communication network for receiving an audio signal and control signals, the control signals altering the operation of the sound masking output circuit, and the audio signal comprising a sound masking signal or a sound masking signal combined with a paging signal; (c) a control unit, the control unit having a communication interface for coupling the control unit to the communication network for transmitting control signals over the communication network to the sound masking units, and the control signals include signals for controlling the operation of at least some of the sound masking units; (d) the digital component for the audio output circuit being responsive to control signals from the programmable controller for amplifying the audio signal received at the sound masking unit.

[0012] In a further aspect, the present invention provides a networked sound masking system for controlling ambient noise level in a physical environment, the networked sound masking system having a communication network for coupling a plurality of sound masking units, the sound masking units span the physical environment, the sound masking units include a sound masking component for outputting a sound masking output signal based on a sound masking signal received from the network and include a communication interface to the communication network for receiving control signals and the sound masking signal over the communication network, and a control unit having a communication interface for coupling the control unit to the communication network for transmitting the sound masking signal and control signals to the sound masking units, and the control signals include signals for selectively controlling the operation of the sound masking units, a computer for generating adjustment signals for the control unit for adjusting characteristics of the sound masking output signal outputted by the sound masking units, the computer comprises: (a) a communication interface for transmitting the sound masking signal and the adjustment signals to the control unit, and the control unit has an external communication interface compatible with the computer communication

interface; (b) an input component for receiving sound level readings for the physical environment; (c) a component responsive to the sound level readings for generating the adjustment signals associated with the characteristics of the sound masking output signal for the sound masking units.

[0013] In yet another aspect, the present invention provides a networked sound masking system having: (a) a communication network spanning at least a portion of the physical environment; (b) a plurality of speaker units, the speaker units include a communication interface for coupling the speaker units to the communication network, and the communication interface having an address component for recognizing control signals and an audio signal for announcement at the speaker unit associated with the address component, and the audio signal comprises a sound masking signal or a sound masking signal mixed with a paging signal; (c) a control unit having a communication interface for coupling the control unit to the communication network for transmitting the audio signal and control signals over the communication network to the speaker units associated with the address component, and the control signals including signals for selectively controlling the operation of the speaker units; (d) the control unit includes an address generator for assigning addresses to the speaker units.

[0014] Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Reference will now be made to the accompanying drawings, which show, by way of example, embodiments of the present invention, and in which:

[0016] Fig. 1 shows in block diagram form a networked sound masking system according to the present invention;

[0017] Fig. 2 shows a master sound masking unit or master hub in block diagram form for the networked sound masking system of Fig. 1;

[0018] Fig. 3(a) shows in block diagram form a control unit for the networked sound masking system of Fig. 1;

[0019] Fig. 3(b) shows in diagrammatic form the control, response and paging channels for the control unit;

[0020] Fig. 4 shows the control unit of Fig. 3(a) in more detail, and in particular the functional modules for the control unit;

[0021] Fig. 5 shows in flowchart form a main functional processing method for the control unit of Fig. 3(a);

[0022] Fig. 6 shows in flowchart form the processing steps for the display/setup function in the control unit for the networked sound masking system according to the present invention;

[0023] Fig. 7 shows in flowchart form the processing steps for the date/time function in the control unit for the networked sound masking system;

[0024] Fig. 8 shows in flowchart form the processing steps for the volume/contour/EQ(Equalizer) functions in the control unit for the networked sound masking system;

[0025] Fig. 9 shows in flowchart form the steps for setting the timer function for the control unit for the networked sound masking system;

[0026] Fig. 10 shows in flowchart form the processing steps for a diagnostics function in the control unit for the networked sound masking system;

[0027] Fig. 11(a) shows in flowchart form the steps for a system configuration function in the control unit for the networked sound masking system;

[0028] Fig. 11(b) shows in flowchart form the steps for configuring addresses for the sound masking units according to an aspect of the present invention;

[0029] Fig. 12 shows in flowchart form the processing steps for the timer function for the control unit;

[0030] Fig. 13 shows in flowchart form a functional processing method for selecting control functions in the master sound masking or master hub units;

[0031] Fig. 14 shows in flowchart form the processing steps for an equalization in the networked sound masking system according to the present invention;

[0032] Fig. 15 shows in flowchart form the processing steps for the switch menu setting functions in the control unit for the networked sound masking system according to the present invention;

[0033] Fig. 16 shows in flowchart form a main functional processing method for an "In room" wall switch according to another aspect of the present invention;

[0034] Fig. 17 shows in flowchart form the processing steps for volume menu setting functions in the control unit for the operation of the "In room" wall switch;

[0035] Fig. 18 shows in flowchart form the processing steps for a unit locator function in the control unit;

[0036] Fig. 19 shows in flowchart form the processing steps for a paging zone and input setting function for the control unit;

[0037] Fig. 20 shows in graphical form a Prescribed Spectrum Contour table for the sound masking signal;

[0038] Fig. 21 shows in block diagram form an "In-room" wall switch for the networked sound masking system according to the present invention;

[0039] Fig. 22 shows in flowchart form the processing steps for a masking zone and input setting function for the control unit;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0040] Reference is first made to Fig. 1, which shows in block diagram form a networked sound masking system according to the present invention and indicated by reference 1.

[0041] As shown in Fig. 1, the networked sound masking system 1 comprises a control unit 2, and a network 10 comprising a plurality of standard master sound masking units or master hub units 14, indicated individually by 14a, 14b, 14c,....14n, one or more master sound masking switch units or master switch hubs 16, one or more master sound masking power units or master power hubs 18, and one or more satellite units or hubs 20, indicated individually by references 20a, 20b, 20c. The physical connections for the network 10 between the master sound masking units 14, 16, 18 may comprise 5 or 4 conductors. In a 5 conductor arrangement, two conductors carry power, two conductors provide a

communication channel for control, sound masking and paging signals, and one conductor provides for ground in an AC powered implementation. (In a DC implementation, the conductor for ground may be eliminated). The conductors are preferably terminated with multi-pin connectors as described below.

[0042] The master hubs 14 serve as junction boxes in the network 10. The master hub switch 16 provides a connection to an "In-room" wall switch 24 located in a physical space, e.g. a room. The In-room wall switch 24 is coupled to the network 10 through the master switch hub 16 or either directly as described below with reference to Fig. 21. As will also be described in more detail below, the In-room switch 24 allows sound masking and paging signal parameters to be adjusted or set locally. The In-room switch 24 may include an integral or separate In-room remote sensor module 26 to allow the settings to be adjusted using a remote control unit 28, for example, a handheld IR or wireless based unit. The master power hub 18 provides power for additional master hubs 14, 16 which are connected to the master power hub 18. As shown in Fig. 1, the master power hub 18 includes a power supply 30 for providing the additional power. The master hub 14d coupled to the master power hub 18 is supplied with additional power from the power supply 30.

[0043] Referring to Fig. 1, the control unit 2 includes a sound masking module 4, and a paging signal module 6. The control unit 2 also includes a power supply unit 32, for example, a DC power supply, for providing a power feed to the units coupled to the network 10. The control unit 2 may also include a communication/control link 34 to a computer 36, for example, a personal computer or PC. Through software the computer 36 provides an interface for configuring, administering, and running diagnostics.The software on the computer 36 also provides the equalization or tuning function as described in more detail below. The software running on the computer 36 may also include a sound masking signal generation function for generating one or more sound masking signals for distribution to the hubs 14 as described in more detail

below. The communication interface 34 provides the capability to access the control unit 2 from a remote location, e.g. within the building or from an offsite location. The communication interface 34 may comprise a wireless link, a telephone communication, radio communication, computer network (e.g. a Local Area Network (LAN) or a Wide Area Network (WAN)), or a connection through the Internet or World Wide Web (WWW). This provides greater flexibility in configuring, adjusting and maintaining the sound masking system 1 from a remote or off-site location, for example, a wireless link or a Wide Area Network or Internet link.

[0044] The computer 36 may be used for tuning the equalization function in the master sound masking hubs 14, 16, 18 as will be described in more detail below with reference to Fig. 14. For the tuning function, the computer 36 is equipped with appropriate software for performing the tuning functions and a microphone 38 or a sound level meter 39. The microphone 38 functions as a transducer to convert acoustical measurements into a form suitable for analysis by the software running on the computer 36. For the tuning function, the computer 36 preferably comprises a notebook computer with a wireless link for the communication link 34.

[0045] As shown in Fig. 1, speakers 22, denoted by individually by references 22a, 22b, 22c, 22d, 22e, 22f, 22g, 22h, 22i,.... plug into the master hubs 14, the switch master hubs 16, the power master hubs 18 and the satellite hubs 20. The individual speakers 22 may comprise devices which are suspended above the ceiling tiles or a speaker integrated with ceiling plate adapter 23 which is mounted in the ceiling surface. It will be appreciated that other types of speaker enclosures and installations are also contemplated. For some installations, it may be advantageous to combine the master hub 14, 16, 18 and speaker 22 in a single or integrated enclosure.

[0046] According to another aspect of the invention, additional control units, indicated individually by reference 3a to 3n, may be coupled to the control unit 2, for example, in a daisy chain configuration. The control unit 3a is coupled to one or more master hubs 17, indicated individually by references 17a, 17b,... 17i, to form another network or zone 15a. As shown, a speaker 23, indicated individually by references 23a, 23b,....23i is coupled to the respective master hub units 17. In addition to the master hub unit 17, the network 15 may include master switch hubs, master power hubs, and satellite hubs as described above. The control unit 3a and network 15a allow a networked sound masking system to be configured for another physical space or zone in a building, e.g. another floor, while still be connected to the control unit 2 in order to provide a centralized control facility. Similarly, the nth control unit 3n is coupled to one or more master hub units 19a, 19b, including a master power unit 19i, and/or master switch unit (not shown) and satellite hubs (not shown). As shown, a speaker 25, indicated individually by references 25a, 25b,....25j, is coupled to the respective master hub units.

[0047] The master sound masking hubs 14a, master switch hubs 16 and master power hubs 18 and the satellite sound masking hubs 20 together with the sound masking module 4 (or the sound masking multiplexer 5 as described with reference to Fig. 5) and the speakers 22 provide the sound masking output functionality. The sound masking signal or signals are generated in the sound masking module 4 and distributed by the control unit 2 to all or selected master sound masking hubs 14 as described in more detail below. Each master sound masking hub 14, 16, 18 (and satellite sound masking hub 20) is configured either individually or as a group for a particular physical space, e.g. office, room, zone in a open office, etc. The master sound masking hubs 14, 16, 18 are configured to output a sound masking output signal received from the control unit 2 at a specified output level for performing the sound masking in the physical space. As will be described in more detail below, the sound masking module 4 generates the sound masking signals according to a programmable

spectrum, and the control unit 2 distributes the sound masking signal(s) to all or selected ones of the master hubs 14. The master hubs 14 may include controls for equalizer, and volume settings. Alternatively, the sound masking signals may be generated through software running on the computer 36. The satellite sound masking units 20 are connected to their associated master unit 14 (16 or 18) and reproduce the sound masking signal generated by the master unit 14. The satellite units 20 provide a cost-effective way to expand the coverage of the master sound masking unit 14 (16 or 18) in a building space.

[0048] The control unit 2 as will be described in more detail couples to the network 10 and provides the capability to selectively distribute/transmit the sound masking signals and/or paging signals to master sound masking hubs 14, 16, 18 and also adjust the functional aspects of the master sound masking hubs 14, 16, 18 and the satellite sound masking hubs 20. The sound masking signal and the paging signal may both be considered as a type of audio signal which is transmitted by the control unit 2 to selectively addressed hubs 14, 16 or 18. The sound masking signal and the paging signal may be transmitted separately, i.e. in different channels, or the sound masking signal and the paging signal may be mixed at the control unit 2 and transmitted as a mixed audio signal in one or more of the audio channels 154 (Fig. 3b). The mixing function for the control unit 2 is described in more detail below with reference to Fig. 4. The sound masking functions include masking signal spectrum, masking signal output volume, paging spectrum and paging volume. The control unit 2 also provides diagnostic functions and timer control functions.

[0049] The control unit 2 configures the network 10 by assigning identities or addresses to each of the master hubs 14, 16, 18. The addressing of the individual master hubs 14, 16, 18 enables the control unit 2 to direct commands and/or status requests to individual master sound masking hubs 14, 16, 18 (and indirectly the associated satellite sound masking hubs 20, i.e. via the master hubs 14, 16, 18), or to groups of master sound masking hubs 14, 16, 18, or to

the entire network 10 as a whole. The control unit 2 is then used to set /adjust the masking signal spectrum, the masking signal volume, and/or the paging spectrum, the paging volume for the selected (i.e. addressed) master hub 14, 16, 18 and the satellite sound masking hub 20. According to another aspect, the master sound masking hubs 14, 16, 18 includes a digital equalizer 68 (Fig. 2) for providing greater programming flexibility over the spectrum for the sound masking signal generated by the selected master and satellite sound masking hubs 14, 16 or 18 and 20. In the master hubs 14, 16, 18 may include another digital equalizer 69 (Fig. 2) for the paging signal.

[0050] Reference is next made to Fig. 2 which shows the master sound masking hub 14 in greater detail. As shown, the master unit 14 comprises a digital signal processing module 50, an audio power amplifier stage 52, an input serial interface 54, an output serial interface 56, and a power supply module 58. The input serial interface 54 and the output serial interface 56 form a communication interface which provides the capability to communicate with the control unit 2 and other master sound masking hubs 14, 16 or 18, and/or the In-room wall switch 24 connected in the network 10. The master hub 14 includes a local power supply 58 for powering the circuitry. The audio power amplifier stage 52 drives the speaker 22 (Fig. 1) which emits the audio signal, i.e. the sound masking signal, the paging signal or a mixed sound masking and paging signal as will be described in more detail below. The audio power amplifier stage 52 also includes an output port 60 for coupling to a satellite hub 20 (Fig. 1).

[0051] The master switch hub 16 (Fig. 1) and the master power hub 18 have essentially the same topology as the master hub 14 depicted in Fig. 2. The master switch hub 16 includes a connection for the In-room wall switch 24 for coupling to the network 10. (Alternatively, the In-room wall switch 24 is connected directly to the network 10). The master power hub 18 (Fig. 1) includes a power input 64. The power input 64 receives a power feed from the auxiliary DC/AC power supply 30 described above with reference to Fig. 1.

[0052] As shown in Fig. 2, the digital signal processing module 50 is implemented as a single chip DSP device such as the MC56F801 available from the Motorola Corporation. The digital signal processing module 50 comprises an output port 66 for the sound masking signal(s) received from the control unit 12, an equalizer module for sound masking 68, an equalizer module for paging 69, a digital-to-analog converter (DAC) stage 70, a switching logic stage 72, and a paging demultiplexer module 74. The digital signal processing module 50 includes a processing unit 76 (i.e. a microprocessor) in addition to on-chip resources such as a memory. The processing unit 76 controls the operation of the modules 68, 69, 70, 72 and 74 to provide the functionality as described in more detail below.

[0053] The audio signals, e.g. the sound masking signal, the paging signal or mixed sound masking and paging signal generated by the control unit 2, are received by the processing unit 76 if they are addressed to the master hub 14. The addressing and decoding function is performed through the switching logic stage 72. The sound masking signal received by the processing unit 76 is outputted at an output port 66 as a sound masking output signal. The sound masking signal is generated at the sound masking module 4 and transmitted by the control unit 2 via the network 10. As shown in Fig. 2, the output port 66 is coupled to the equalizer 68.The equalizer 68 is implemented in firmware as a function or routine executed by the processing unit 76 and allows the spectrum for the sound masking output signal to be altered or varied before output to the DAC 70.

[0054] The equalizer module 68 comprises a 1/3 Octave equalizer which is used for adjusting the sound spectrum of the noise signal output to the desired contour. The equalizer module 68 for the sound masking signal provides twenty-three (23) bands. In the present embodiment, the 1/3 Octave Band frequencies comprise 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250,

1600, 2000, 2500, 3150, 4000, 5000, 6300, 8000, and 10,000 Hertz (Hz). The output from the equalizer module 68 is a contoured sound masking output signal, i.e. the sound masking output signal with a controllable contour. The contoured sound masking output signal is outputted through the DAC module 70 to the amplifier power stage 52.

[0055] The DAC module 70 input to the amplifier power stage 52 functions to convert the digital sound masking output signal into an analog signal equivalent.

[0056] The audio power stage 52 provides an amplified output level for the contoured sound masking signal. The contoured sound masking output signal is amplified by the audio power stage 52 and output to the connected speaker 22 which emits a sound masking sound into the physical space. The audio power stage 52 also provides an amplified output for a mixed sound masking signal and a paging signal, where the paging signal which may comprise announcements, emergency notifications, background music or other broadcasts over the speaker. The output level of the audio power stage 52 is controllable by the processing unit 76 through the digital conversion of the input signal which is fed to the audio power stage 52.

[0057] The equalizer 69 for the paging signal, and the paging demultiplexer 74 are also implemented in firmware as functions executed by the processing unit 76. The equalizer module 69 for the paging signal will typically have a fewer number of bands. The equalizer module 68 and the equalizer module 69 may be combined into a single unit and under control of the processing unit 76 the appropriate equalization bands are applied based on the type of audio signal, i.e. a sound masking signal, a paging signal, or a mixed sound masking and paging signal.

[0058] According to another embodiment, the firmware for the processing unit 76 may include a function or routine for mixing at the master sound masking

hubs 14, 16 or 18 the sound masking signal and the paging signal received in separate audio channels (Fig. 3b) over the network 10.

[0059] Referring to Fig. 2, the switching logic stage 72 together with the input serial interface stage 54 and the output serial interface stage 56 form a communication interface, indicated by reference 55 for the master hub 14. The communication interface 55 couples the processing unit 76 in the DSP 50 to the network 10 (Fig. 1) and allows the master hub14 to receive the sound masking signal, control commands and also to transmit responses. Paging signals/audio data sent by the control unit 2 over the network 10 are also received via the communication interface 55. The switching logic stage 72 connects the processing unit 76 to the input and output serial interface stages 54 and 56. The input serial interface 54 allows the processing unit 76 to communicate with an upstream device, for example, the master sound masking unit 14a (Fig. 1) or the control unit 2 (Fig. 1). The output serial interface stage 56 allows the processing unit 76 to communicate with a downstream device, for example, the master sound masking switch hub 16 (Fig. 1). In conjunction with the switching logic stage 72, the processing unit 76 monitors the serially encoded messages and acts upon messages which are addressed to the specified master sound masking hub 14. Each of the master sound masking hubs 14, 16 and 18 is assigned an address according to a self-addressing mechanism as will be described in more detail below.

[0060] The satellite sound masking hubs 20 (Fig. 1) are associated with respective master sound masking hubs 14, 16 or 18. The satellite sound masking hubs 20 are connected to a speaker 22, and are coupled to one of the master sound masking hubs 14, 16 or 18. The satellite sound masking hubs 20 act as slaves or satellites to the master sound masking hub 14 (16 or 18) and reproduce the audio signal output, i.e. sound masking signal, paging signal or mixed sound masking and paging signal output, generated by the associated master sound masking hub 14 (16 or 18).

[0061] Reference is next made to Fig. 3(a), which shows the control unit 2 in more detail. As shown, the control unit 2 comprises a processor unit (i.e. a microprocessor) 80, a program memory 82, a data memory 84, a display module 86, a keypad 88, a real-time clock module 90, a parameter memory 92, a first serial communication interface 94, a communication interface 96, and a second serial communication interface 98.

[0062] The first serial communication interface 94 couples the control unit 2 to the master sound masking hub 14, 16, or 18 in the network 11 (Fig. 1). The second serial communication interface 98 provides a communication interface for coupling the control unit 2 to the other control unit 3a (Fig. 1). The communication interface 96 provides the communication link to the computer or PC 34 as described above with reference to Fig. 1. As described above, the computer 34 may also be used to generate the sound masking signals for the control unit 2.

[0063] As shown, the sound masking module 4 is also coupled to the control unit 2. In another aspect, the sound masking module 4 may be replaced by a sound masking signal multiplexer 5. The sound masking signal multiplexer 5 includes an analog-to-digital converter, and the sound masking signal multiplexer 5 has a number of inputs indicated generally by reference 7 for receiving analog sound masking input signals. In another embodiment, the sound masking signal multiplexer 5 may comprise a digital multiplexer for receiving multiple sound masking signals in digital format. The sound masking signals are in the form of audio signals with sound masking characteristics.

[0064] Under the control of the processing unit 80 one of the sound masking signal inputs 7 is selected in the multiplexer 5. If in analog format, the selected sound masking signal input 7 is converted into corresponding digital signals in the analog-to-digital stage. The digitized sound masking signal is then inserted

into one of a number of audio data channels 154 (Fig. 3(b)), or mixed with a paging signal as described in more detail below. As shown in Fig. 3(b), the communication channels for the system 10 comprise a control channel 150, a response channel 152, and eight audio data channels 154, indicated individually by references 154a, 154b, 154c, 154d, 154e, 154f, 154g, and 154h. According to this aspect, the control unit 2 sends control signals to one or more selected master sound masking hubs 14, 16, 18 (Fig. 1) based on the address of the hubs. If required, the addressed hubs 14, 16, 18 can send a message back to the control unit 12 via the response channel 152. For the sound masking signals, one or more of the master hubs 14, 16, 18, i.e. belonging to a sound masking or acoustic zone, are sent control signals indicating the audio data channel 154 from which the sound masking signal is to be selected for output on the speakers associated with the selected master sound masking hubs 14, 16, 18 (Fig. 1) and any satellite sound masking hubs 20 (Fig. 1). The addressability of the master sound masking hubs 14, 16, and 18 allows sound masking or acoustic zones to be defined which provide the capability to send different sound masking signals to different master hubs 14, 16, 18 and/or different groups of master hubs 14, 16, 18.

[0065] For the embodiment using the sound masking module 4 (Fig. 1), the digitally generated sound masking signal(s) are inserted into one or more of the audio channels 154 (Fig. 3(b), indicated individually by references 154a, 154b, 154c, 154d, 154e, 154f, 154g, and 154h. As described above, one or more of the master hubs 14, 16, 18, i.e. belonging to a sound masking or acoustic zone based on the addresses of the hubs, are sent control signals indicating the audio data channel 154 from which the sound masking signal is to be selected for output on the speakers associated with the selected master sound masking hubs 14, 16, 18 (Fig. 1) and any satellite sound masking hubs 20 (Fig. 1).

[0066] According to another aspect, the system 1 may include a built-in paging function. As shown in Fig. 3(a), the control unit 2 also includes another

multiplexer having an analog-to-digital converter stage indicated by reference 81 for the paging function. The multiplexer stage 81 has a number of inputs 83 for receiving analog paging signal inputs. Under the control of the processing unit 80 one of analog paging signal inputs is selected in the multiplexer 81. The selected analog paging signal input is converted into corresponding digital signals in the analog-to-digital stage. The digitized paging signal is then inserted into one of the audio data channels 154, indicated individually by references 154a, 154b, 154c, 154d, 154e, 154f, 154g, and 154h in Fig. 3(b). According to this aspect, the control unit 2 sends control signals to one or more selected master sound masking hubs 14, 16, 18 (Fig. 1) based on the address of the hubs. If required, the addressed hubs 14, 16, 18 can send a message back to the control unit 2 via the response channel 152. For the paging signals/audio data, one or more of the master hubs 14, 16, 18, i.e. belonging to a paging zone, are sent control signals indicating the paging channel 154 from which audio data is to be selected for output on the speakers associated with the selected master sound masking hubs 14, 16, 18 (Fig. 1) and any satellite sound masking hubs 20 (Fig. 1). The addressability of the master sound masking hubs 14, 16, and 18 allows paging zones to be defined which provide the capability to send different paging signals to different master hubs 14, 16, 18 and/or different groups of master hubs 14, 16, 18. According to another embodiment, the paging signal is mixed with the sound masking signal and then inserted into one or more of the audio channels 154

[0067] Reference is next made to Fig. 4, which shows functional modules in the control unit 2 for performing various functions associated with the networked sound masking system 10. The control unit 2 includes a functional module 100 for providing time of day and date functions, a functional module 102 to control an 1/n Octave equalizer for the paging feature, a functional module 104 for providing paging zones and selecting the paging signal for the paging zones, a functional module 105 for providing sound masking zones and selecting the sound masking signal for the sound masking and acoustic zones, a functional

module 106 for adjusting the frequency spectrum of the audio signal output, i.e. the sound masking signal or paging signal, for one or more of the hubs 14, 16 or 18 according to preset equalization functions, a functional module 108 to provide timer functions for the system 1, a functional module 109 to provide timer zone/schedule set-up functions, a functional module 110 to control communication functions with the computer 36 (Fig. 1), the master hubs 14, 16, 18 (Fig. 1), and the In-room switch 24 (Fig. 1), a functional module 112 to select the sound masking signal(s) from the sound masking generator module 4 (Fig. 1) or from the sound masking multiplexer 5 (Fig. 3(a)), a functional module 116 to provide system configuration functions (including self-addressing, i.e. the addressing of the master sound masking hubs 14, 16, 18 in the network 11), a functional module 118 for locating particular hubs or units in the network, a functional module 120 for performing diagnostic functions, and a functional module 122 for processing inputs from the In-room switch 24 (Fig. 1). The operation of the functional modules in the control unit 12 is now described in more detail with reference to the flowcharts in Figs. 5 to 19.

[0068] As shown in Fig. 4, the control unit 2 also includes a functional module 114 to provide a mixing function for the sound masking signal(s) and/or paging signals. This allows the sound masking signal(s) to be mixed with the paging signal centrally and transmitted as an audio signal in one of the audio channels 154 (Fig. 3b) to all or selected master hubs 14, 16, 18 via the network. According to another embodiment, the sound masking and paging signals are transmitted as separate audio signals in separate audio channels 154 (Fig. 3b) and the mixing function is performed under firmware control by the digital signal processing module 50 in the master sound masking hub 14 as described above with reference to Fig. 2.

[0069] Reference is first made to Fig. 5, which shows a start-up process 200 for the control unit 2. The start-up process 200 is executed in response to a power-up 202 or a reset condition. The start-up process 200 comprises an initialization step 204 which includes configuring the control unit 12. After the

initialization step 204, the control unit 12 runs a timer operation 206, a switch operation 208, and a display/setup operation 210. The display/setup operation 210 is executed as a background task, for example, in a polling loop. The timer operation 206 is periodically executed, for example, on an interrupt driven basis or as part of a polling loop in the display/setup operation. The switch operation 208, i.e. sensing inputs from the In-room switch 24 (Fig. 1) is also periodically executed.

[0070] Reference is next made to Fig. 6, which shows the display/setup operation 210 in more detail. As shown the display/setup operation 210 comprises displaying a series of menu functions on the display 86 (Fig. 3) which are accessed via selections from the keypad 88 (Fig. 3). As shown in Fig. 6, the menu functions include a Date/Time function menu 212, a Volume function menu 214, a Contour menu function 216, a Unit (i.e. hub) Locator function menu 218, an Equalizer Setting function menu 220, a Switch function menu 222, a Masking Zone/Input function menu 223, a Noise Generation function menu 224, a Paging Zone/Input function 225, a Mixing function menu 226, a Timer Zone/Schedule function menu 227, a Diagnostic function menu 228, a System Configuration function menu 230, and Serial Number function menu 232. According to another aspect, the functionality of the control unit 2 may be implemented in the computer 36.

[0071] The processing steps for the Date/Time function menu 212 are shown in Fig. 7. The first step comprises displaying the time of day 240 and prompting the user to change the time of day 242. If the user selects to change the time of day, then a set time procedure 244 is executed. Otherwise the date is displayed 246, and the user is prompted to change the date 248. If the user selects to change the date, a set date procedure 250 is executed.

[0072] Reference is next made to Fig. 8, which shows in more detail the processing steps for setting the Audio (i.e. the masking and paging signals)

Volume function 214, the Contour Control function for the audio signal 216, and the Equalizer (EQ) Band function 220 for the audio signal (i.e. the masking signal and/or the paging signal). The steps for controlling each of these functions for the audio signal is implemented according to a process 260 as illustrated in Fig. 8. As shown, the first step in block 262 comprises selecting the master sound masking hub. In decision block 264, a selection is made between a single master sound masking hub14, 16, 18 or multiple master sound masking hubs14, 16 and/or 18 or all multiple master sound masking hubs 14, 16 and/or 18. If multiple master sound masking hubs14, 16, 18 are to be configured, then the next step 266 involves selecting the range for the sound masking hubs 14, 16, 18. The level for the sound masking hubs 14, 16, 18 in the range is entered in block 268 and transmitted via the network 10 to all the sound masking hubs 14, 16, 18 in the selected range. After the level has been sent to the sound masking hubs 14, 16, 18 in the range, in block 270, and the first sound masking unit 14a in the range is selected, i.e. addressed, in block 272.

[0073] Referring still to Fig. 8, the next step in block 274 involves reading the level setting for the master sound masking hub14, 16 or 18 which was selected in step 272 or as a result of the branch from decision block 264. The level setting received from the sound masking hub 14, 16 or 18 is compared to the desired setting stored in the control unit 2, and if a change in the level is needed as determined in decision block 276, then the desired level setting is sent to the selected master sound masking hub 14, 16 or 18 in block 278. If no change is indicated for the selected master sound masking hub 14, 16 or 18, then the next master sound masking hub 14, 16 or 18 in the network 10 is selected, i.e. addressed, in block 280 and the steps 274 and 276 are repeated. The same processing steps are utilized for setting the Audio Signal Volume function 214, the Contour Control function 216, and the Equalizer Band functions 220 for the audio signals (i.e. the sound masking and the paging signals).

[0074] Reference is next made to Fig. 9, which shows in more detail the processing steps for the Timer Zone/Schedule function menu 227. The first step in block 290 comprises setting timer zones in the network 10. The next step involves selecting the zone in block 292. Next in block 294, timer schedules, timer profiles, ramp-up schedules and exception dates are displayed for the selected zone, and the user is prompted to enter a change in the timer settings. If a change is entered (decision block 296), then the entry is stored in memory as indicated in block 298. The timer zones are independent from the switch and paging zones. The timer schedules may include pre-programmed profiles, such as, standard office settings, regular office hours, and executive office settings for ramp-up, timer schedules and exception dates. The ramp-up feature provides the capability to set timed schedules for ramping up the sound masking output level. Exception dates are programmed for dates such as holidays, and override the regular timer schedule.

[0075] Reference is next made to Fig. 10, which shows the operation of the diagnostic menu 228 and function 120 (Fig. 4) for the control unit 2 in more detail. The first step 300 involves the control unit 2 selecting the first of the master sound masking hubs14, 16 or 18 for the diagnostic test. In response, the control unit 2 retrieves the serial number from the master sound masking hub 14, 16, 18 over the network 10 as indicated by block 302. If there is an error (as indicated by decision block 304), then a communication error (in block 306) is logged for that hub14, 16 or 18 and another hub14, 16 or 18 is selected in block 320. If there is no communication error (decision block 304), then the control unit 2 checks the serial number against the entry stored in a lookup table in block 308. If the serial number does not match the entry in the lookup table, then an identification error is logged in block 312, and another master sound masking hub 14, 16 or 18 is selected in block 320. If the serial number matches the entry in the lookup table (decision block 310), then the status for the master sound masking hub 14, 16 or 18 is queried by the control unit 2 in block 314. The status of the selected master sound masking hub 14, 16 or 18 is checked in

block 316, and if the status is fail or does not meet specifications, then a status error is logged in block 318. The next step in block 320 involves selecting another master sound masking hub 14, 16 or 18 and repeating steps 302 through 320, as described above, until all, or the selected group, of the master sound masking hubs 14, 16 or 18 have been queried as determined in block 322. The last step in the operation of the diagnostic function module 120 comprises generating and/or displaying a diagnostics report as indicated in block 324.

[0076] Reference is next made to Fig. 11(a), which shows the operation of the system configuration and self addressing functional module 116 and menu function 230 for the control unit 2 in more detail. The control unit 2 is preferably password protected, and the first step 330 involves prompting the user to enter a password. If the password is incorrect (decision block 332), then further access is denied (block 334). If the entered password is correct, the password is displayed in block 336, and the user is given the option of changing the password (decision block 338). If the user changes the password, then the new password is saved in block 340. The next step 342 involves displaying the number of master sound masking hubs 14, 16, 18 that are presently configured for the network 10. If the system 1 is being setup for the first time, the number of hubs or units may be configured at the factory or entered in the field by the technician. The user is given the option of changing the number of hubs 14, 16, 18 configured for the system 1 in decision block 344, and the new number of hubs 14, 16, 18 is stored in step 346.

[0077] Referring still to Fig. 11(a), in decision block 348, the user is prompted to initialize the system 1. If the user elects to initialize the system 1, then the control unit 2 executes an initialization procedure indicated generally by reference 350. The initialization procedure 350 is shown in more detail in Fig. 11(b). As shown, the first step 352 in the initialization procedure 350 involves resetting all of the master sound masking hubs 14, 16, 18 connected to the

network 10. As a result of the reset operation 352, each of the master sound masking hubs 14, 16, 18 has a logical address of 0. Since all of the hubs 14, 16, 18 have logical address 0, the first sound masking hub 14, 16 or 18, i.e. the master hub 14a, responds when the control unit 2 queries the hubs 14, 16, 18 as indicated by block 354. The selected hub 14, 16, 18 is then queried for its serial number in block 356. The serial number is assigned to the hub 14, 16, 18 at the time of manufacture and preferably comprises a code stored in non-volatile memory in the hub 14, 16, 18. The control unit 2 uses the serial number to generate a unit address, i.e. logical address, for the hub 14, 16, 18 as indicated in block 358. The serial number is preferably stored in memory, for example a look-up table in the control unit 2, and provides a cross-reference to the master sound masking hub 14, 16, 18. The current logical address generated in step 358 is unique for the master hub 14, 16, 18 in the present network configuration for the system 1, but for another network configuration the logical addresses may be regenerated. Following the addressing operation, the next sound masking hub 14 is selected by the control unit 2 and the current logical address is incremented for the next sound masking hub 14, 16, or 18. The operations for assigning the current logical address to the master sound masking hub 14, 16, 18 based on the serial number according to steps 356 to 360 are repeated. These operations are repeated until all of the sound masking hubs 14, 16, 18 have been assigned current logical addresses by the control unit 2 as indicated by decision block 362. Following this scheme, the current logical address for the last sound masking hub 14, 16, 18 is equal to the number of sound masking hubs 14, 16, 18 connected to the networked system 1.

[0078] Reference is next made to Fig. 12, which shows the timer function 206 (Fig. 5) in more detail. In response to an interrupt or a request from a polling loop, a wake-up call or "clock tick" is periodically issued as indicated in step 370, and a schedule of timed events is checked in block 372. The timed events may comprise, for example, changes in the level of the sound masking signal for all or some of the master sound masking hubs 14, 16, 18 (and the associated

satellite sound masking hubs 20). If the schedule indicates that there is no change in sound masking level, then the timer function 206 goes to sleep (block 376). If there is a scheduled change, then the new level for the sound masking signal is transmitted via the network 10 to the affected sound masking hubs 14, 16, 18 (block 378).

[0079] Reference is next made to Fig. 13, which shows in flowchart form a method for selecting control functions in the control unit 2 for controlling the master sound masking units 14. As shown, the control functions 400 include an initialization procedure 401, a program serial number procedure 402, a read serial number procedure 403, an assign logical address procedure 404, a read level procedure 405, and a write level procedure 406.

[0080] The initialization procedure 401 comprises a function 408 for resetting the logical addresses and a function 410 for writing logical addresses for the master sound masking hubs 14, 16, 18 as described above with reference to Fig. 11. The program serial number procedure 402 provides a mechanism for programming or regenerating the serial number stored in non-volatile memory for each hub 14, 16, 18. The procedure 402 comprises a write serial number function 412. The read serial number procedure 403 comprises a read serial number function 414 which the control unit 2 utilizes to read the serial numbers of the hubs 14, 16, 18, for example, as described above with reference to Fig. 11. The assign logical address procedure 404 comprises a write address function 416 for writing, i.e. assigning, logical addresses to the sound masking hubs 14, 16, 18. The read level procedure 405 comprises a read level function 418 which allows the control unit 2 to read the current levels for the various settings for the hubs 14, 16, 18 being addressed by the control unit 2 or by an In-room switch. The write level procedure 406 comprises a write level function 420 which allows the control unit 2 to write the level for the selected function for the sound masking signal in the master sound masking hub 14, 16, 18 being addressed by the control unit 2. Once the master sound masking

hub14, 16, 18 is selected, the control unit 2 next selects the function to be queried/programmed, and then reads the parameter setting using the read level function 418, or writes the parameter setting, using the write level function 420.

[0081] As described above, the master sound masking hubs 14, 16, 18 according to the present invention include an equalizer stage 68 (Fig. 2) which allows the shaping of the sound spectrum of the sound masking noise signal output. In addition, the hubs 14, 16, 18 also includes the second equalizer stage 69 (Fig. 2) to allow for shaping the spectral characteristics of the paging signal. Advantageously, the capability to address each of the sound masking hubs allows the equalizer stages 68, 69 to be individually set for each of the hubs 14, 16, 18 or a group of the hubs 14, 16, 18, and this capability greatly enhances the functionality of the networked sound masking system 1 according to the present invention. In another embodiment, the two equalizer stages 68 and 69 (Fig. 2) may be combined into one equalizer stage which operates on the spectral characteristics of the sound masking signal, the paging signal or a mixed sound masking signal and paging signal, as these signals take the form of an audio signal which is transmitted to the hubs 14, 16, or 18 and processed by the processing unit 66 (Fig. 2) as described above with reference to Fig. 3(b).

[0082] Reference is made to Fig. 14 which shows a procedure 430 according to another aspect of the invention for controlling the equalizer function in each of the sound masking hubs 14, 16, 18. According to this aspect, the equalizer functions are performed in the computer 36. The computer 36 and the microphone 38 are used to take sound level readings for the physical space. Calculated control settings based on these readings are transmitted by the computer 36 via the communication link 34, e.g. wireless link, to the control unit 2, which then transmits control data to the hubs 14, 16, 18 affected. As will now be described with reference to Fig. 14, the readings from the microphone 38 or the sound level meter 39 are used in conjunction with settings in a Prescribed Contour Table stored in the computer 36 to adjust the level settings in the

equalizer stages 68 for the master sound masking hubs 14, 16, 18. It will be appreciated that the Prescribed Contour Table defines the ideal sound masking levels for the physical space, and the levels are programmable or user-definable.

[0083] As shown in Fig. 14, the first operation in the equalization procedure 430 comprises receiving the unit ID(s) (entered by a user or technician) to select the sound masking hub or hubs 14, 16, 18 on which the equalizer function is to be adjusted/programmed (block 431). The next step in block 432 involves selecting the equalization adjustment or tuning mode. If auto tuning mode is selected, then the next step in block 434 involves reading (and displaying) the current sound levels. Next in block 436, the sound levels are compared to prescribed settings stored in memory. The prescribed levels are user definable and may be determined, for example, by identifying acceptable sound level readings in decibels (dB) by band, with one band for every 1/n octave in the equalizer. A prescribed setting may comprise, for example, a 63 Hz band center at 46 dB +/- 2 dB. If the measured sound levels are within an acceptable range of the prescribed settings, then the auto-tuning procedure is concluded. If not within an acceptable range, then the equalization levels are modified by the computer 36 and applied to the relevant sound masking hubs 14, 16, 18 via the control unit 2, as indicated in block 438. Measurements for the modified levels set in block 438 are then taken as indicated in block 440, and these measurements are again compared to the prescribed settings as indicated in block 442. If the modified levels are within an acceptable range, then the auto-tuning procedure is concluded. If the measurements corresponding to the modified levels are not within the acceptable range as determined in block 442, then the required equalizer settings are calculated in block 443 and they are compared to the equalizer setting limits in block 444. The setting limits define maximum or minimum equalization settings, for example, zero (0) as the minimum and one hundred (100) as the maximum. As indicated, a comparison is made to determine if the required equalizer settings are "below minimum",

"above maximum", or "within limits". If the required equalizer settings are within limits, then steps 438 to 442 are repeated. If the required equalizer settings are below minimum, then the frequency band(s) corresponding to those levels are eliminated. If the required equalizer settings are above maximum, then the equalizer settings are set to maximum in block 448.

[0084] Referring again to Fig. 14, in manual mode, the first step in block 450 involves taking sound level measurement and displaying the levels associated with those measurements. Next a decision is made to change the equalizer settings or to keep them the same in block 452, and if necessary the equalizer settings are changed in block 454. The process may then be repeated in step 450.

[0085] As described above, the computer 36 and the microphone 38 or the sound level meter 39 provide an effective mechanism for adjusting the equalizer function in each of the sound masking hubs 14, 16, 18 through the control unit 2 and networked connection without the need for opening the ceiling tile to physically access any of the master sound masking units 14, 16, 18.

[0086] As shown in Fig. 1, the In-room wall switch 24 is provided in a physical space, e.g. meeting room, and is connected to the master switch hub 16 or alternatively the In-room wall switch 24 is coupled directly to the network 11. The In-room wall switch 24 provides the capability for an occupant to manually adjust the output characteristics of the master hubs 14, 16 or 18 (and the associated speakers 22) configured to be associated with the In-room wall switch 24. The In-room wall switch 24 may include the In-room remote sensor 26 for use with the In-room remote control 28, for example, a handheld wireless IR device. The In-room wall switch 24 may be implemented as depicted in Fig. 21.

[0087] As shown in Fig. 21, the In-room wall switch 24 comprises a switch panel 470, a display 472, a processing unit 474, and a communication interface

476. The communication interface 476 couples the In-room wall switch 24 to the master sound masking switch hub 16 or directly to the network 10. The communication interface 476 comprises a first serial interface module 478, a switching logic stage 480, and a second serial interface module 482. The processing unit 474 uses the switching logic stage 480 to send control messages and receive display messages from the master switch hub 16 or the control unit 2 via the network 10. The processing unit 474 uses the display 472 to display status and operating information, typically received from the control unit 2. As shown, the switch panel 470 comprises an adjust volume up button 486, an adjust volume down button 488, and a mute button 490. Depressing the up button 486 increases the output level of the audio output signal (i.e. the sound masking output signal, the paging signal, or the mixed sound masking and paging signal), while depressing the down button 488 decreases the output level of the audio output signal. The mute button 490 allows the audio signal output, i.e. sound masking or paging, to be muted.

[0088] According to another aspect, the In-room wall switch 24 may be provided with an interface 489 for receiving control signals from the In-room remote sensor 26 and the wireless remote 28. The wireless remote 28 provides the functionality of the switch panel 470, i.e. up and down adjust, mute, in a portable handheld unit.

[0089] Reference is next made to Fig. 15, which shows the operation of the switching function module 122 and the switch menu 22 for the control unit 2. The first step 500 as shown in Fig. 15 comprises selecting the first In-room switch 26. The next step 502 involves assigning one or more of the master hubs 14, 16 or 18 to the selected switch 24. The process is repeated for the next In-room switch 26 as indicated in block 504.

[0090] Reference is next made to Fig. 16, which shows the primary operations performed by the processing unit 474 in the In-room wall switch 24

(Fig. 21). In block 514, the parameters associated with the selected function are read, and then sent to the control unit 2 (i.e. via the response channel 152 (Fig. 3(b)). The control unit 2 then executes the change for the hubs 14, 16, 18 or 20 associated with that In-room switch 24.

[0091] Reference is next made to Fig. 17 which shows the processing steps executed by the control unit 2 for the operation of the volume setting inputs from the In-room wall switch 26. The first step performed by the control unit 2 in block 520 involves selecting the first In-room wall switch 26 via the master switch hub 16 which is coupled to the In-room switch 26 through the communication interface 476 (Fig. 21). Once the In-room switch 26 is selected, the control unit 2 determines the audio signal output level (i.e. the masking signal output, the paging signal output, or the mixed masking signal and paging signal output) from values stored in memory (block 522). Next the control unit 2 determines if there is a change in the audio signal output volume level in block 524. As described above with reference to Fig. 21, a change in volume level is initiated by depressing continuously or repeatedly the up or down button. In response, the control unit 2 sends a control message to the master sound masking hubs 14, 16, 18 programmed or associated with the In-room wall switch 24. The control message corresponds to the level setting as determined from the In-room wall switch 24. If no change is indicated for the In-room wall switch 24 in block 534, then the next In-room wall switch 24 in the network 10 is selected and the processing steps are repeated as described above.

[0092] Reference is next made to Fig. 18 the processing steps for the unit locator function 118 (Fig. 4) and the locator menu function 218 (Fig. 6) in the control unit 2. The first step indicated in block 540 involves selecting the master sound masking hub 14, 16 or 18 in the network 10. Once selected, the control unit 2 sends a locator message or signal to the selected hub 14, 16 or 18 in step 542.

[0093] Reference is next made to Fig. 19 the processing steps for the paging zone/input function 104 (Fig. 4) and the paging zone/input menu function 224 (Fig. 6) in the control unit 2. The first step indicated in block 550 involves selecting one of the paging zones configured for the installation. Next, one or more of the hubs 14, 16 or 18 is assigned to the selected paging zone as indicated in block 552. Next in step 554, one of the paging inputs 83 (Fig. 3) is assigned from one of the audio channels 154 (Fig. 3(b)) which has been assigned to the hub or group of hubs 14, 16, 18. The selected paging input is played over the associated speakers 22 for the hubs 14, 16, 18 (and 20) which belong to the paging zone. It will be appreciated that in certain instances, for example in an emergency situation, the paging zone for a paging signal will include all the hubs 14, 16, 18 irrespective of the paging zones. Next, the control unit 2 in step 556 selects the next paging zone and repeats the steps described above.

[0094] Reference is next made to Fig. 22, which shows the processing steps for the masking zone/input function 105 (Fig. 4) and the masking zone/input menu function 223 (Fig. 6) in the control unit 2. The first step indicated in block 560 involves selecting one of the sound masking zones configured for the installation. Next, one or more of the hubs 14, 16 or 18 is assigned to the selected masking zone as indicated in block 562. Next in step 564, one of the sound masking inputs 7 (Fig. 3(a)) is assigned from one of the audio channels 154 (Fig. 3(b)) which has been assigned to the hub or group of hubs 14, 16, 18. The selected sound masking signal input is outputted to the associated speakers 22 for the hubs 14, 16, 18 (and 20) which belong to the masking zone. Next, the control unit 2 in step 566 selects the next masking zone and repeats the steps described above. According to another embodiment, the sound masking signal(s)are generated internally by the sound masking module 4 and assigned to selected audio channels 154 (Fig. 3(b)) and transmitted to the hubs 14, 16, 18 belonging to the selected masking zone. The selection between the

different sources for the sound masking signal input is controlled by the function 112 in the control unit 2 as shown in Fig. 4.

[0095] The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Certain adaptations and modifications of the invention will be obvious to those skilled in the art. Therefore, the presently discussed embodiments are considered to be illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.